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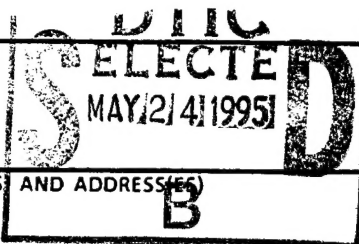| 1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 04-12-95	3. REPORT TYPE AND DATES COVERED Final June 1, 1993 - November 30, 1994

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12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words) Training protocols for complex skills were designed and tested employing video game-like representative analogues of complex skills, which are emerging as powerful tools for understanding the cognitive processes involved in acquiring complex skills. Separate experiments examined attention control, interaction anxiety, observational learning, intersession spacing, competition, and discussion during intersession intervals. Articles related to these experiments have been published, submitted for publication, or prepared for publication. The data have also been stored as SAS files for future analyses by interested scientists. A theme for future analyses will be treating the separate experiments as converging operations for testing theories of automatic and controlled processes during the acquisition and performance of complex skills. Initial steps in this analysis have suggested a theory of explicit and implicit learning ensembles during a novice's acquisition that are paralleled by orchestrated automatic and control processes during an expert's performance. This theory will be formally presented in an invited contribution to the Attention and Performance Conference XVII. The contribution will also consider these empirical and theoretical analyses from the points of view of researchers and practitioners as an integrated foundation for understanding and improving training protocols for computer-based training of individuals and groups.

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COGNITIVE FACTORS IN AUTOMATED INSTRUCTION
FOR INDIVIDUALS AND GROUPS

A Final Report submitted to the
Air Force Office of Sponsored Programs
by
Wayne Shebilske
Texas A&M University

The short term goals of the research were a) to complete the
analysis of data from fourteen thousand subject hours that were
collected in the TRAIN laboratory during my tenure as a National
Research Council Research Associate, b) to publish results of
individual experiments, and c) to participate in the design of
subsequent experiments. The research was done in collaboration
with Wes Regian and other scientists affiliated with the TRAIN
laboratory or with Texas A&M University.
       The long term goal was to build an empirical and theoretical
foundation for deriving pedagogical principles for automated
instruction. Automated instruction was defined as training and
education delivered on a microprocessor-based system. Accordingly,
the basic understanding and principles that were sought should be
applicable to, but not limited to, computer assisted instruction,
computer-based training, simulator-based training, interactive
videodisc-based training, computerized part-task training, and
intelligent tutoring systems.
       The short term goals were accomplished:
a) Data from fourteen thousand subject hours were analyzed and
stored in SAS files that are available for future analysis by us
and other scientists upon request.

b) The following articles, which are published, submitted for
publication, or in preparation acknowledge the funding of this
grant:

       Arthur, W., Strong, M., Williamson, J., Jordan, J., Shebilske,
W., & Regian, W. (1995). Visual Attention: Individual Differences
in Predicting Complex Task Performance. Acta
Psychologica.

       Johnston, A.N., Regian, J.W., & Shebilske, W.L. (1994).
Observational learning and training of complex skills in laboratory
and applied settings. Proceedings of the WEAAP (Western European
Association for Aviation Psychology) 21st Conference, Dublin,
Ireland.

       Shebilske W.L., Corrington, K., and Jordan, J. (1994) Massed
versus distributed practice in complex skill acquisition.
Proceedings of the 38th-Annual Meeting of the Human Factors
Society, Vol. 2.

Connolly Gomez, C., Shebilske, W.L., & Regian, J.W. (1994) The effect of training on cognitive capacity demands for synthetic speech. Proceedings of the 38th-Annual Meeting of the Human Factors Society, Vol. 2.

Goettl, B.P., Yadrick, R.M., Connoly Gomez, C., Regian, W.J., & Shebilske, W.L. (in press). Alternating Task Modules in isochronal distributed training of complex tasks. Journal of the Human Factors Society.

Corrington, K. & Shebilske W.L. (under review) Spacing effects in complex skill acquisition and maintenance. Journal of the Human Factors Society.

Prislin, R., Jordan, J. A., Tschan-Semmer, F. & Shebilske, W. (under review). The effects of group discussion on acquisition of complex skills.

Arthur, W., Jr., Young, B.S., Jordan, J.A., & Shebilske, W.L. (under review). Effectiveness of individual and dyadic training protocols: The influence of trainee interaction anxiety. Journal of the Human Factors Society.

Regian, J.W., Day, E.A., & Shebilske, W. (in preparation). The role of the skill acquisition specialist in the directed evolution of human-machine systems.

Shebilske, W.L., Jordan, J.A., & Prislin, R. (in preparation) Competition and performance on a computer-based complex perceptual-motor task.

c) These data and publications provided a foundation for the questions addressed and the methods used in many subsequent experiments in the TRAIN Laboratory and my laboratory.

Significant progress has also been made toward the long term goal of developing an empirical and theoretical foundation for understanding and improving automated instruction of complex skills. This foundation integrates the present research with other related research. It will be integrated further during the Attention and Performance Conference XVII at which I have been invited to present. The presentation will be based on the research done during this project and will therefore acknowledge the support of this grant. The concluding paragraphs of this final report summarize the presentation that will be made and thereby summarizes progress toward our long term goal.

Guided by theoretical analyses of control strategies, researchers have designed and tested training protocols for complex skills. Many of the tests have employed video game-like representative analogues of complex skills, which are emerging as powerful tools for understanding the cognitive processes involved in acquiring complex skills. Separate experiments within this line

of research have improved our understanding of such topics as visual attention, hierarchical task decomposition, observational learning, and transfer of skills from computer game simulators to actual flight. Collectively, these experiments serve as converging operations for testing theories of control strategies. We analyzed these converging operations and supplemented them with instruments for directly assessing a trainee's explicit control strategies while learning a representative analogue of a complex skill. We also used process dissociation techniques to reflect implicit control of automatic processes. Based on this broad empirical foundation, we propose a theory of Explicit and Implicit Learning Ensembles (Eileen) in the acquisition of automated and controlled processes for complex skills. Explicit learning processes include elaboration, problem diagnosing, and solution planning, which results in controlled processes such as explicit attention control strategies. Implicit learning processes involve the strengthening of connections entailed by concurrent events, which results in automatic processes such as open-loop motor control. These complementary parts contribute to a unified and balanced learning and control process. The orchestration of implicit and explicit learning processes during a novice's acquisition of a complex skill is parallelled by the orchestration of automatic and controlled processes during an expert's performance of a complex skill. An expert's controlled processes not only maintain exclusive control over some components of complex tasks, but also share responsibilities over other components that are the primary responsibility of automatic processes. Normally, the shared responsibility is nothing more than monitoring the outcome of automatic processes. When the automatic processes fail, however, the controlled processes momentarily take over. The parallel orchestration of implicit and explicit learning and control ensembles has implications for training complex skills. For example, the effectiveness of two training protocols, Multiple Emphasis on Components (MEC), and Active Interlocked Modeling (AIM)-Dyad, can be explained in terms of promoting these parallel orchestrations. Our presentation will detail these explanations and extend them to the evaluation of other training protocols including intelligent tutors. Finally, these empirical and theoretical analyses will be considered from the points of view of researchers and practitioners as an integrated foundation for understanding and improving training protocols for computer-based training of individuals and groups.